AMENDMENTS TO THE CLAIMS

Please amend the claims as set forth below. Claims 2 and 6 are cancelled without prejudice. Claims 14-24 are newly added.

1. (Currently Amended) A transmitter for transmitting complex symbols in a wireless communication system, comprising:

four transmitting antennas; ~~and~~

an phase rotator for inputting four symbols to transmit, and multiplying two symbols from among the four symbols by predetermined phase values for the two symbols to output two phase-rotated symbols; and

an encoder for carrying out a negation and conjugation operation of two symbols from among the four symbols containing the two phase-rotated symbols ~~configuring four combinations for four input symbols so that a sequence of four symbols can be transmitted once by each antenna~~ during each time interval, and for transferring the four symbols after the negation and conjugation operations ~~combinations~~ to the transmitting antennas.

~~wherein at least two symbols selected form the four input symbols are each rotated by predetermined phase values~~.

2. (Cancelled)

3. (Currently Amended) The transmitter as set forth in claim 1, wherein the phase values are determined within a range of 21° to 69° ~~with a center of 45°~~ where QPSK (Quadrature Phase Shift Keying) is used for transmitting the complex symbols through the four transmitting antennas.

4. (Currently Amended) The transmitter as set forth in claim 1, wherein the phase values are determined within a range of 21° to 24° where 8PSK (8-ary Phase Shift Keying) is used for transmitting the complex symbols through the four transmitting antennas.

5. (Currently Amended) The transmitter as set forth in claim 1, wherein the phase values are determined to 11.25° where 16PSK (16-ary Phase Shift Keying) is used for transmitting the complex symbols through the four transmitting antennas.

7. (Currently Amended) The transmitter as set forth in claim ~~6~~ 1, wherein ~~the four combinations configured by the four input symbols form~~ the encoder generates a four by four matrix ~~consisting of four rows and four columns~~, the matrix being given by:

$$\begin{bmatrix} e^{j\theta_1}s_1 & s_2 & s_3^{*} & e^{-j\theta_4}s_4^{*} \\ s_2^{*} & -e^{-j\theta_1}s_1^{*} & e^{j\theta_4}s_4 & -s_3 \\ s_3 & e^{j\theta_4}s_4 & -e^{-j\theta_1}s_1^{*} & -s_2^{*} \\ e^{-j\theta_4}s_4^{*} & -s_3^{*} & -s_2 & e^{j\theta_1}s_1 \end{bmatrix}$$

where s_1, s_2, s_3 and s_4 denote the input symbols, and θ_1 and θ_4 denote phase values for phase-rotating the symbols s_1 and s_4, respectively.

8. (Currently Amended) The transmitter as set forth in claim ~~6~~1, wherein the encoder generates ~~four combinations configured by the four input symbols form~~ a four by four matrix ~~consisting of four rows and four columns~~, the matrix being given by one among the following matrices:

$$\begin{bmatrix} x_1 & x_2 & x_3^{*} & x_4^{*} \\ x_2^{*} & -x_1^{*} & x_4 & -x_3 \\ x_3 & x_4 & -x_1^{*} & -x_2^{*} \\ x_4^{*} & -x_3^{*} & -x_2 & x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & x_3^{*} & -x_4^{*} \\ x_2^{*} & -x_1^{*} & x_4 & x_3 \\ x_3 & x_4 & -x_1^{*} & x_2^{*} \\ x_4^{*} & -x_3^{*} & -x_2 & -x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & x_3^{*} & -x_4^{*} \\ x_2^{*} & -x_1^{*} & -x_4 & -x_3 \\ x_3 & x_4 & -x_1^{*} & x_2^{*} \\ x_4^{*} & -x_3^{*} & x_2 & x_1 \end{bmatrix}$$

$$\begin{bmatrix} x_1 & x_2 & x_3^{*} & x_4^{*} \\ x_2^{*} & -x_1^{*} & -x_4 & x_3 \\ x_3 & x_4 & -x_1^{*} & -x_2^{*} \\ x_4^{*} & -x_3^{*} & x_2 & -x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & -x_3^{*} & -x_4^{*} \\ x_2^{*} & -x_1^{*} & x_4 & -x_3 \\ x_3 & x_4 & x_1^{*} & x_2^{*} \\ x_4^{*} & -x_3^{*} & -x_2 & x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & -x_3^{*} & x_4^{*} \\ x_2^{*} & -x_1^{*} & x_4 & x_3 \\ x_3 & x_4 & x_1^{*} & -x_2^{*} \\ x_4^{*} & -x_3^{*} & -x_2 & -x_1 \end{bmatrix}.$$

$$\begin{bmatrix} x_1 & x_2 & -x_3^{*} & -x_4^{*} \\ x_2^{*} & -x_1^{*} & -x_4 & x_3 \\ x_3 & x_4 & x_1^{*} & x_2^{*} \\ x_4^{*} & -x_3^{*} & x_2 & -x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & -x_3^{*} & x_4^{*} \\ x_2^{*} & -x_1^{*} & -x_4 & -x_3 \\ x_3 & x_4 & x_1^{*} & -x_2^{*} \\ x_4^{*} & -x_3^{*} & x_2 & x_1 \end{bmatrix}$$

where x_1, x_2, x_3 and x_4 denote four symbols output from the phase rotator ~~containing two phase rotated symbols~~.

9. (Currently Amended) The transmitter as set forth in claim ~~6~~1, wherein the encoder generates ~~four combinations configured by the four input symbols form~~ a four by four matrix ~~consisting of four rows and four columns~~, the matrix being given by:

$$\begin{bmatrix} e^{j\theta_1}s_1 & e^{j\theta_2}s_2 & e^{-j\theta_3}s_3^* & e^{-j\theta_4}s_4^* \\ e^{-j\theta_2}s_2^* & -e^{-j\theta_1}s_1^* & e^{j\theta_4}s_4 & -e^{j\theta_3}s_3 \\ e^{j\theta_3}s_3 & e^{j\theta_4}s_4 & -e^{-j\theta_1}s_1^* & -e^{-j\theta_2}s_2^* \\ e^{-j\theta_4}s_4^* & -e^{-j\theta_3}s_3^* & -e^{j\theta_2}s_2 & e^{j\theta_1}s_1 \end{bmatrix}$$

where s_1, s_2, s_3 and s_4 denote the input symbols, and θ_1 and θ_4 denote phase ~~rotation~~ values for phase-rotating the symbols s_1, s_2, s_3, and s_4, respectively.

10. (Currently Amended) A receiver for receiving complex symbols in a wireless communication system, comprising:

a symbol arranger for receiving signals transmitted from four transmitting antennas to at least one receiving antenna during four time intervals;

a channel estimator for estimating four channel gains ~~indicating gains~~ of channels from the four transmitting antennas to the at least one receiving antenna;

first and second decoders each producing metric values associated with all possible symbol sub-combinations using the channel gains and the signals received by the symbol arranger and detecting two symbols having a minimum metric value among all the possible symbol sub-combinations, each of the symbol sub-combinations containing all possible two symbols; and

a parallel-to-serial converter for sequentially arranging and outputting the two symbols detected by each of the first and second decoders.

11. (Currently Amended) The receiver as set forth in claim 10, wherein each of the first and second decoders comprises:

a symbol generator for generating all the possible symbol sub-combinations ~~each of the symbol sub-combinations containing the two symbols~~

a phase rotator for rotating one symbol ~~selected~~ from the two symbols of each of the symbol sub-combination by a predetermined phase value

a metric calculator for producing the metric values for the symbol sub-combinations containing the phase-rotated symbol using the signals received by the symbol arranger and the channel gains; and

a detector for detecting the two symbols having the minimum metric value using the produced metric values.

12. (Currently Amended) The receiver as set forth in claim 11, wherein the first decoder detects two symbols s_1 and s_3 capable of minimizing ~~an equation~~ the matrix value of

$\left|R_1 - e^{j\theta_1} s_1\right|^2 + \left|R_3 - s_3\right|^2 + \left|R_{13} - e^{-j\theta_1} s_1^* s_3\right|^2 - \left|s_1\right|^2 \left|s_3\right|^2$ in which R_1, R_3 and R_{13} are given by:

$$R_1 = \left(\frac{r_1 h_1^* + r_2^* h_2 + r_3^* h_3 - r_4 h_4^*}{K}\right), R_3 = \left(\frac{r_1 h_4^* + r_2^* h_3 - r_3^* h_2 + r_4 h_1^*}{K}\right) \quad and \quad R_{13} = \left(\frac{-h_1 h_4^* + h_1^* h_4 - h_2^* h_3 + h_2 h_3^*}{K}\right)$$

and $K = |h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2$ where r_1, r_2, r_3 and r_4 denote the signals received during the four time intervals, and h_1, h_2, h_3 and h_4 denote the channel gains of four antennas.

13. (Currently Amended) The receiver as set forth in claim 11, wherein the second decoder detects two symbols s_2 and s_4 capable of minimizing ~~an equation~~ the metric value of $\left|R_2 - s_2\right|^2 + \left|R_4 - e^{j\theta_4} s_4\right|^2 + \left|R_{24} - s_2^* e^{j\theta_4} s_4\right|^2 - \left|s_2\right|^2 \left|s_4\right|^2$ in which R_2, R_4 and R_{24} are given by:

$$R_2 = \left(\frac{r_1 h_2^* - r_2^* h_1 + r_3^* h_4 + r_4 h_3^*}{K}\right), R_4 = \left(\frac{r_1 h_3^* - r_2^* h_4 - r_3^* h_1 - r_4 h_2^*}{K}\right) \quad and \quad R_{24} = \left(\frac{-h_2 h_3^* - h_1^* h_4 + h_4^* h_1 + h_3 h_2^*}{K}\right)$$

and $K = |h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2$ where r_1, r_2, r_3 and r_4 denote signals received during the four time intervals, and h_1, h_2, h_3 and h_4 denote the channel gains of four antennas.

14. (New) A method for transmitting complex symbols in a wireless communication system having four transmitting antennas, the method comprising the steps of:

multiply two from symbols among four input symbols by predetermined phase values for the two symbols, to output two phase-rotated symbols;

selecting one of a four by four matrix such that the four symbols containing the two phase-rotated symbols are transmitted through the four transmitting antenna;

generating a new four by four matrix by carrying out a negation and a conjugation operation of at least one element among elements of the selected four by four matrix; and

~~selecting~~ sequentially selecting one column of the new four by four matrix during each time interval, and transferring complex symbols of the selected column to the transmitting antennas.

15. (New) The method as set forth in claim 14, wherein the phase values are determined within a range of 21° to 69° where QPSK (Quadrature Phase Shift Keying) is used for transmitting the complex symbols through the transmitting antennas.

16. (New) The method as set forth in claim 14, wherein the phase values are determined within a range of 21° to 24° where 8PSK (8-ary Phase Shift Keying) is used for transmitting the complex symbols through the transmitting antennas.

17. (New) The method as set forth in claim 14, wherein the phase values are determined to 11.25° where 16PSK (16-ary Phase Shift Keying) is used for transmitting the complex symbols through the transmitting antennas.

18. (New) The method as set forth in claim 14 wherein the generated new four by four matrix is given by:

$$\begin{bmatrix} e^{j\theta_1}s_1 & s_2 & s_3^* & e^{-j\theta_4}s_4^* \\ s_2^* & -e^{-j\theta_1}s_1^* & e^{j\theta_4}s_4 & -s_3 \\ s_3 & e^{j\theta_4}s_4 & -e^{-j\theta_1}s_1^* & -s_2^* \\ e^{-j\theta_4}s_4^* & -s_3^* & -s_2 & e^{j\theta_1}s_1 \end{bmatrix}$$

where s_1, s_2, s_3 and s_4 denote the input symbols, and θ_1 and θ_4 denote phase values for phase-rotating the symbols s_1 and s_4, respectively.

19. (New) The method as set forth in claim 14, wherein the generated new four by four matrix is given by one of the following matrices:

$$\begin{bmatrix} x_1 & x_2 & x_3^* & x_4^* \\ x_2^* & -x_1^* & x_4 & -x_3 \\ x_3 & x_4 & -x_1^* & -x_2^* \\ x_4^* & -x_3^* & -x_2 & x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & x_3^* & -x_4^* \\ x_2^* & -x_1^* & x_4 & x_3 \\ x_3 & x_4 & -x_1^* & x_2^* \\ x_4^* & -x_3^* & -x_2 & -x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & x_3^* & -x_4^* \\ x_2^* & -x_1^* & -x_4 & -x_3 \\ x_3 & x_4 & -x_1^* & x_2^* \\ x_4^* & -x_3^* & x_2 & x_1 \end{bmatrix}$$
$$\begin{bmatrix} x_1 & x_2 & x_3^* & x_4^* \\ x_2^* & -x_1^* & -x_4 & x_3 \\ x_3 & x_4 & -x_1^* & -x_2^* \\ x_4^* & -x_3^* & x_2 & -x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & -x_3^* & -x_4^* \\ x_2^* & -x_1^* & x_4 & -x_3 \\ x_3 & x_4 & x_1^* & x_2^* \\ x_4^* & -x_3^* & -x_2 & x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & -x_3^* & x_4^* \\ x_2^* & -x_1^* & x_4 & x_3 \\ x_3 & x_4 & x_1^* & -x_2^* \\ x_4^* & -x_3^* & -x_2 & -x_1 \end{bmatrix}$$
$$\begin{bmatrix} x_1 & x_2 & -x_3^* & -x_4^* \\ x_2^* & -x_1^* & -x_4 & x_3 \\ x_3 & x_4 & x_1^* & x_2^* \\ x_4^* & -x_3^* & x_2 & -x_1 \end{bmatrix} \begin{bmatrix} x_1 & x_2 & -x_3^* & x_4^* \\ x_2^* & -x_1^* & -x_4 & -x_3 \\ x_3 & x_4 & x_1^* & -x_2^* \\ x_4^* & -x_3^* & x_2 & x_1 \end{bmatrix}$$

where x_1, x_2, x_3 and x_4 denote four phase-rotated symbols.

20. (New) The method as set forth in claim 14, wherein the generated new four by four matrix is given by:

$$\begin{bmatrix} e^{j\theta_1}s_1 & e^{j\theta_2}s_2 & e^{-j\theta_3}s_3^* & e^{-j\theta_4}s_4^* \\ e^{-j\theta_2}s_2^* & -e^{-j\theta_1}s_1^* & e^{j\theta_4}s_4 & -e^{j\theta_3}s_3 \\ e^{j\theta_3}s_3 & e^{j\theta_4}s_4 & -e^{-j\theta_1}s_1^* & -e^{-j\theta_2}s_2^* \\ e^{-j\theta_4}s_4^* & -e^{-j\theta_3}s_3^* & -e^{j\theta_2}s_2 & e^{j\theta_1}s_1 \end{bmatrix}$$

where s_1, s_2, s_3 and s_4 denote the input symbols, and θ_1 and θ_4 denote phase values for phase-rotating the symbols s_1, s_2, s_3, and s_4, respectively.

21. (New) A method for receiving complex symbols in a wireless communication system, the method comprising the steps of:

receiving signals transmitted from four transmitting antennas to at least one receiving antenna during four time intervals;

estimating four channel gains of channels from the four transmitting antennas to the at least one receiving antenna;

producing metric values associated with all possible symbol sub-combinations using the channel gains and the received signals, and detecting two symbols having a minimum metric value

among all the possible symbol sub-combinations, each of the symbol sub-combinations containing all possible two symbols; and

sequentially arranging and outputting the two detected symbols.

22. (New) The method as set forth in claim 21, wherein the detecting step comprises:

generating all the possible symbol sub-combinations;

rotating a phase of one symbol from the two symbols of the each symbol sub-combination by a predetermined phase value;

producing the metric values for the symbol sub-combinations containing the phase-rotated symbol using the received signals and the channel gains; and

detecting the two symbols as the two symbols having a minimum metric value using the produced metric values.

23. (New) The method as set forth in claim 21, wherein the detecting step detects two symbols s_1 and s_3 capable of minimizing the metric value of $\left|R_1 - e^{j\theta_1} s_1\right|^2 + \left|R_3 - s_3\right|^2 + \left|R_{13} - e^{-j\theta_1} s_1^* s_3\right|^2 - \left|s_1\right|^2 \left|s_3\right|^2$ in which R_1, R_3 and R_{13} are given by :

$$R_1 = \left(\frac{r_1 h_1^* + r_2^* h_2 + r_3^* h_3 - r_4 h_4^*}{K}\right), R_3 = \left(\frac{r_1 h_4^* + r_2^* h_3 - r_3^* h_2 + r_4 h_1^*}{K}\right) \quad and \quad R_{13} = \left(\frac{-h_1 h_4^* + h_1^* h_4 - h_2^* h_3 + h_2 h_3^*}{K}\right)$$

and $K = |h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2$ where r_1, r_2, r_3 and r_4 denote the signals received during the four time intervals, and h_1, h_2, h_3 and h_4 denote the channel gains of four antennas.

24. (New) The receiver as set forth in claim 21, wherein the detecting step detects two symbols s_2 and s_4 capable of minimizing the metric value of

$\left|R_2 - s_2\right|^2 + \left|R_4 - e^{j\theta_4} s_4\right|^2 + \left|R_{24} - s_2^* e^{j\theta_4} s_4\right|^2 - \left|s_2\right|^2 \left|s_4\right|^2$ in which R_2, R_4 and R_{24} are given by:

$$R_2 = \left(\frac{r_1 h_2^* - r_2^* h_1 + r_3^* h_4 + r_4 h_3^*}{K}\right), R_4 = \left(\frac{r_1 h_3^* - r_2^* h_4 - r_3^* h_1 - r_4 h_2^*}{K}\right) \quad and \quad R_{24} = \left(\frac{-h_2 h_3^* - h_1^* h_4 + h_4^* h_1 + h_3 h_2^*}{K}\right)$$

and $K = |h_1|^2 + |h_2|^2 + |h_3|^2 + |h_4|^2$ where r_1, r_2, r_3 and r_4 denote signals received during the four time intervals, and h_1, h_2, h_3 and h_4 denote the channel gains of four antennas.

REMARKS

Claims 1-24 are pending in the application with Claims 1, 10 and 14 as independent claims. Claims 14-24 are newly added. The Examiner has rejected Claims 1-9 under 35 U.S.C. §102(e) as being anticipated by Papadias et al. (U.S. Pub. No. 2003/0174782). Claim 10 is provisionally rejected on the ground of nonstatutory double patenting over Claim 1 of co-pending application No. 10/692,896. Claim 10 is further rejected under 35 U.S.C. §103(a) as being unpatentable over Walton et al. (U.S. Publication No. 2004/0120411) in view of Naguib (US Pub-2003/00864479.

Reconsideration of this Application is respectfully requested.

It is gratefully acknowledged that Claims 11-13 would be allowed if rewritten in independent form including all the limitations of the base claim and any intervening claims.

Papadias discloses a method and apparatus for reducing the bit rate of multi-input systems that employ space-time coding by displacing in signal space the derivatives of a symbol. A mapped particular symbol is space-time coded to generate transmit-sequences having a phase-shifted version of the particular symbol, the phase shifted version and the particular symbol differing in phase by an amount other than by 90°, 180°, and 270°. (See Abstract).

Regarding the rejection of Claim 1 under 35 U.S.C. §102(e), Claim 1 has been amended and is distinguished over the prior art of record.

Regarding the double patenting rejection of independent Claim 10, Applicants respectfully reserve the right to address this issue when and if Claim 1 of copending Application No. 10/692,896 is allowed. Furthermore, Claim 10 has been amended to obviate the obviousness rejection. Amended Claim 10 recites novel features not taught, disclose or fairly suggested by the prior art of record.

As such, amended independent Claim 1 is believed to be allowable over the prior of record.

Accordingly, reconsideration and withdrawal of the 35 U.S.C. § 102(e) rejection of Claim 1 is respectfully requested. Amended Claim 10 has also been amended and is believed to be allowable over the prior of record.

Claims 2-9, 11-12 and 15-24 depend from independent Claims 1, 10 and 14. Therefore, without conceding the patentability per se of dependent Claims 2-9, 11-12and 15-24, they are believed to be patentably distinguished over *Papadias* and the combination of *Walton,* and *Naguib*, based on their respective dependency from independent Claims 1, 10 and 14. Accordingly, reconsideration and withdrawal of the rejections of Claims 1-24 are respectfully requested.

Accordingly, all of the claims pending in the Application, namely, Claims 1-24,are believed to be in condition for allowance. Should the Examiner believe that a telephone conference or personal interview would facilitate resolution of any remaining matters, the Examiner may contact Applicants' attorney at the number given below.

Respectfully submitted,

Michael J. Musella
Reg. No. 39,310
Attorney for Applicant

THE FARRELL LAW FIRM
333 Earle Ovington Blvd.
Uniondale, New York 11553
Tel: (516) 228-3565
Fax: (516) 228-8475

MJM/EC/mk